Stimulating GMO-free breeding for organic agriculture: a view from Europe

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In the mid-90s the organic agricultural sector decided not to allow the use of GMOs in organic production. This was partly due to the risks of undesired and unknown environmental and health-related side effects of GMOs. But the main reason was a more ethical choice of respecting the integrity of plants and animals. The decision to remain GMO-free is incorporated in the Basic Standards of the International Federation of Organic Agriculture Movements (IFOAM) and hence applies worldwide. These standards define how organic products are produced, processed and handled. Most organic certification bodies use these standards for certification purposes.

A new vision for organic plant breeding

European organic agriculture is greatly dependent on the conventional seed industry. Organic farmers use modern productive varieties, bred for a high-input farming system with the use of chemicals. Although these varieties yield better than the old land races, they are not adapted to specific organic conditions. They lack traits like nutrient uptake efficiency, early soil coverage against weeds, broad field tolerance against pests and diseases etc. This was hardly an issue in the organic sector in The Netherlands until the threat of GMO varieties put it on the agenda. Space was thus created for a thorough discussion on the suitability of current plant breeding techniques for organic agriculture.

Louis Bolk Institute, a private research institute for organic agriculture, organised a discussion with all key players in the organic and conventional sectors (organic farmers, traders, commercial plant breeders and researchers of national agricultural research institutes) in the Netherlands. This resulted in a vision on organic plant breeding that was further discussed at workshops throughout Western Europe in order to formulate a common standpoint for those involved in organic seed production. The findings were finalised at a recent workshop by a group of European key players (organic sector, commercial seed enterprises). The resulting proposal was forwarded to IFOAM for incorporation in the Basic Standards for Organic Agriculture.

Avoiding undesired cross-pollination. Photo: Louis Bolk Institute

Cross pollination within natural barriers Photo: Louis Bolk Institute

Principles of organic farming as the basis

Judging the suitability of plant breeding methods is based on the principles of organic farming. Organic farming is not merely the avoidance of chemical fertilisers, pesticides and GMOs. It takes the living soil as a basis and uses methods which stimulate (agro-)ecological processes, without exhausting natural resources. Being founded on the integrity and intrinsic value of living entities like the soil, plants, animals and human beings, organic farming respects the environment, farm ecology and the complexity of nature. This attitude of respect prevents farmers from taking actions that affect a plant's reproductive potential and impede the sustainable use of cultivars.

Thus, the concept of organic plant breeding as formulated by the European key players reads as follows: "*The aim of organic plant breeding is to develop plants which enhance the potential of organic farming and bio-diversity. Organic plant breeding is a holistic approach that respects natural crossing barriers and is based on fertile plants that can establish a viable relationship with the living soil.*"

Biodiversity - an essential feature

As biodiversity is one of the main features of a sustainable organic farming system, the organic sector places great value on the free exchange of the genepool. The rights of breeders are respected but patents and techniques to make plants sterile endanger the free exchange, and consequently the genetic diversity. One of the techniques to prevent free exchange of genetic diversity is the utilisation of *cytoplasmic male sterility* without restorer genes to produce hybrids (see Box p.14). The absence of restorer genes prevents the production of seeds and hence this type of hybrids should be forbidden. All other types of hybrids produce viable seeds. They do not maintain purity after multiplication at the farm, but can still be used for developing new varieties.

Seed saving is not practised in the highly specialised horticultural sector in Europe. Dutch organic farmers prefer to buy their seeds, and most of them prefer hybrids. The uniformity of the plants allows for mechanical harvesting and reduces the requirement of seasonal labour that is scarce. Whether hybrids are the best option for the South depends very much on the socio-economic circumstances. Often there are valid arguments against hybrids. Low-income farmers who do not have sufficient funds to buy new seeds every year are better off with varieties that they can multiply inexpensively.

The cell level divide

The biotechnological techniques used in modern plant breeding (see Box p.14) can be divided into those that stay within the realm of life and those that go beyond. If the cell is considered the lowest organised structural entity of life, then all breeding techniques that intervene below cell level do not conform to the organic principles. This means that genetic modification (which interferes at DNA level) and protoplast fusion should be forbidden for the organic sector. All other cell biological techniques, including embryo rescue techniques and in vitro-pollination, are acceptable.

A few plant breeders are willing to go further: not only banning the techniques that go below cell level, but also avoiding those that intervene at cell level. The proposed certification system will label the latter as "organic varieties". Varieties that respect the standards for organic breeding, but go beyond plant level, will be labelled as "organic seeds". "Organic seeds" come from conventional breeding programmes, which respect the organic breeding standards and are multiplied under organic growing conditions for at least one generation.

Re-thinking plant breeding

For the breeders who want to work with as little biotechnology as possible, the challenge is to develop new concepts and breeding strategies that make it redundant. Most biotechnological techniques in plant breeding are used to introduce specific genetic resistance traits from wild relatives and other species into modern cultivars. This has led to a disproportionate reliance on resistant genes and negligence of other characteristics and techniques that prevent the build-up of diseases and pests. For example, the build-up of soil-borne fungal diseases is delayed in cereals, which are taller and have a more open plant structure (opposed to the compact short straw types). Growing varietal mixtures and intercropping also prevents disease epidemics. An organic breeding strategy would therefore aim at compensating for low genetic resistance with a better plant structure and varieties that perform well in mixtures. In this way it would not rely just on a single resistant gene, but on a larger, more sustainable set of measures. Breeding with as little biotechnology as possible requires a rethinking of what we want to achieve and how we can reach our goals. The principles of organic agriculture can help us with this task.

The breeding fields of Vitalis, a Dutch organic breeding company
Photo: Louis Bolk Institue

Setting standards for organic breeding

The development of new varieties requires considerable financial investments. As a relatively small sector, organic farming in Europe depends largely on conventional seed breeders for new varieties. Setting standards for organic plant breeding can influence technology development for the organic sector. These standards specify the techniques allowed for the development of new varieties. To make the implementation of these standards feasible, the private (conventional) seed sector has been involved in the discussions on organic breeding from the beginning.

'Think twice before you act': EU blocks new GM crops to be released

GM Crops such as Bt-maize, RR soybean and Bolgard cotton, are widely accepted in the United States, but public opinion in Europe continues to be increasingly sceptical to GMOs. Only 11 GM varieties were licensed for cultivation in the European Union before an informal moratorium was introduced in 1998 as compared to some 50 GM varieties that are commonly planted in the US, Canada and Argentina.

Last October, EU governments rejected the idea of lifting this three-year ban on importing and planting of new GM crops. Environment ministers spoke against plans to restart licensing GM seeds. Biotech companies like Monsanto and Novartis have been waiting for years to start selling their new varieties of modified maize, soy bean, etc. in the EU. A total of 13 GM varieties are awaiting approval. In 1998, a number of EU countries said they would not allow any new GMOs into the EU until tough rules on testing, labelling and tracing were put in place. Before such an operational system will be implemented it could take another two years, or even longer if the issue of environmental liability has to be turned into law as well.

In non-EU member Switzerland, the release of genetically altered plants into the environment is also forbidden. The government states that, on the basis of current knowledge, it is not possible to gauge the dangers to humans and the environment of the release of such organisms. This precautionary principle by (some of) the EU countries and neighbouring Switzerland is an important acknowledgement of the fact that GM crops are different from "naturally" improved varieties. 'Think twice before you act' seems to be the European answer to GM crops.

Sources: www.ictsd.org/weekly, and www.nzz.ch/english/swiss_week

The formulation of standards for organic plant breeding gives the seed companies clarity on what is expected from them. Some companies in the Netherlands, like Vitalis Biologische Zaden, are willing to adhere to these standards and breed organic seed without using the undesirable biotechnologies.

The standards for organic plant breeding do not indicate how the actual varieties should look like. Louis Bolk Institute helps farmers to formulate their specific wishes (i.e. adaptation to organic soil, tolerance to problematic diseases etc.) by way of crop ideotypes. Seed companies are requested to provide varieties, which comply with these ideotypes for trials on farmers' fields. The trials are evaluated in the field with farmers and breeders. Here a platform of discussion between breeders and farmers is created. The exchange of knowledge stimulates the development of varieties, which better meet the needs of the farmers and are more adapted to an organic farming system. ■

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Biotechnological Techniques applied in Plant Breeding

At cell level

Embryo culture Ovary culture In-vitro pollination	Used for crossing of closely related species, such as cultivated tomatoes and wild relatives. Such crosses occur in nature but do not result in viable seeds as the embryos are aborted prematurely. When these organs are separated from the plant and grown in test tubes, they develop into mature plants.
In-vitro selection	Mostly used to select new varieties, which are tolerant to stress conditions, such as salinity. Plants are grown in test tubes containing a salt solution. Plants that survive are selected.
Anther culture Microspore culture	Pollen and anthers are grown in-vitro. These male sexual organs are not fertilised and hence contain only half a set of chromosomes. This set is doubled with chemicals to get plants that are genetically identical.
Meristem culture Micro propagation Somatic Embryogenesis	This is used for a rapid propagation of plants with an identical genetic make-up. Plant cells are multiplied in test tubes and these cells are regenerated into new plants.

Below cell level

Genetic modification Protoplast fusion	Genetic material of unrelated species that do not cross in nature are inserted into cells. Protoplast fusion implies the merging of complete cells. In genetic modification only small pieces of foreign DNA are inserted into the cell.
Cytoplasmatic Male Sterility (CMS) without restorer genes	Used to produce parent lines for hybrid production which are male sterile. A plant cell is merged with a cytoplast (a plant cell of which the chromosomes are removed). The cell plasma of the cytoplast contains factors, which cause male sterility. CMS does occur in nature, but is accompanied with factors that neutralise the male sterility. When CMS is transferred from an unrelated species into a crop, without the neutralising factors (restorer genes), the new male sterile plants can not be multiplied in nature.
DNA marker assisted selection	Certain sequences of DNA can be associated with certain plant traits. These sequences (markers) can be used to select plants for characteristics, which are not directly visible in the field, such as drought tolerance. This technique makes use of available DNA sequences in the plant cells, but does not change them, and is acceptable for organic agriculture. Sometimes radiation or genetically modified enzymes are used to detect these markers, which is not acceptable for organic farming. Detection can be done with substances that are permitted by organic agriculture such as fluorescence.